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VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING  
RESEARCH

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**VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH**

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- Signal Estimation
- Discrimination
- System Engineering.

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## SECTION I

### INTRODUCTION AND SUMMARY

This quarterly report summarizes the progress made during the period from 1 December 1974 to 31 March 1975 on the VELA Network Evaluation and Automatic Processing Research program being carried out by Texas Instruments Incorporated at the Seismic Data Analysis Center (SDAC) in Alexandria, Virginia. The five tasks of the program are:

- Evaluation of the Korean Seismic Research Station (KSRS)
- Investigation of signal detection techniques
- Investigation of signal estimation techniques
- Investigation of discrimination techniques
- System Engineering Studies.

Software to edit and reformat KSRS data is being developed. When complete, it will allow the use of Texas Instruments long- and short-period array evaluation packages on KSRS short-period data. These packages will be used to evaluate the noise and signal characteristics at the Korean Array during the remainder of the contract.

The signal detection algorithms previously developed have been modified to establish a fixed alarm rate. A non-causal quality check which eliminates bad channels has been developed, and execution time has been reduced. Future plans are to process a large group of data to determine the best detector configuration.

A study of the adaptive beamforming technique as applied to interfering short-period signals has been completed, and a report prepared.

Work will continue on a long-period interfering event study, and on the development of a distributed signal model.

A data base and software for the short-period regional and teleseismic discrimination study are under preparation. Preliminary evaluation of some first-zone events has shown that P to S phase energy ratio is an effective discriminant. The Herrin-Tucker network magnitude bias model has been expanded to allow for non-uniformity in station detection thresholds, and a report has been written. It is planned to spend the remainder of the contract period on the spectral analysis of the regional and teleseismic data, and on the time and frequency domain analysis of the first-zone data.

Group velocity analysis of Rayleigh and Love waves is now possible using the Interactive Long Period Processing System. Evaluation of the performance of the interactive system has begun, and work is complete on interfacing the system with data from the Seismic Research Observatories. In the future, the matched filtering package will be modified to accommodate short-period data.

## SECTION II

### PRELIMINARY EVALUATION OF SHORT-PERIOD KSRS ARRAY

#### A. CURRENT STATUS

The preliminary evaluation of the KSRS short-period array will take place in two parts. The first is the development of software to handle KSRS data, and the second is the actual analysis of the data. During this quarter progress was made on the first of these parts.

An edit program to produce KSRS edit tapes compatible with Texas Instruments short-period NORSAR software has been developed and is being currently checked out. Required modifications to the NORSAR software are also under way. NORSAR short-period programs can thus be used to analyze KSRS data.

Work has begun on a reformatting program for this data. When complete, this program will reformat short-period data into TI's standard long-period format. These data will then appear on tape just as long-period data do. These tapes will be compatible with TI's long-period array evaluation package, after some modification to that package. Then frequency-wavenumber analysis, available only in the long-period package, can be used without further development.

The KSRS data available at the SDAC covers two time periods - spring of 1973 and November, 1974. Representative data samples from each period have been plotted, and it was found that the 1973 data are probably of unacceptable low quality. The data from 1974 appear to be normal.



B. FUTURE PLANS

In the immediate future, we plan to complete the reformatting program and the modifications to the existing evaluation package. The remainder of the next quarter will be devoted to an evaluation of the noise and signal characteristics at KSRS, and the preparation of a report.

### SECTION III

#### SIGNAL DETECTION TECHNIQUES

##### A. CURRENT STATUS

The combined Fisher and conventional power detector algorithm developed under Contract VT/4705 for short-period signals, has been modified to establish a variable detection threshold, which maintains the alarm rate at a fixed, predetermined level. Such a threshold was found to be essential to an optimum detector because of the rapidly varying noise levels at the KSRS. The quality control algorithm has been made non-causal, so that it drops bad channels from consideration before they enter the beamforming process. A preliminary improvement of the software has resulted in a reduction of the execution time to about two thirds of the real duration of the data processed.

##### B. FUTURE PLANS

During the next quarter the detectors under study will be used to process seismic events from the Kuriles-Kamchatka region, if an adequate detection log for this region can be obtained. Otherwise, data from the whole of Eurasia will be used. The detector configuration with the best probability of detection will be determined, and a report written.

## SECTION IV

### SIGNAL ESTIMATION TASK

#### A. CURRENT STATUS

A study of the adaptive beamforming technique as applied to interfering short-period events recorded at KSRS has been completed during this quarter. It was concluded that the ABF technique produces only 6 dB gain relative to simple beamforming in this application, because of poor site-to-site signal similarity and of rapidly changing relative channel power. This study was done on spring 1973 data, and it might change significantly if high quality data were used. A report has been submitted.

#### B. FUTURE PLANS

During the next quarter, the signals estimation task will concentrate in two basic areas. The first is a continuation of the long-period adaptive beamforming interfering-event study, which will concentrate on the effect of changes in processing parameters such as azimuthal and time separation between events. The second area is Wiener distributed signal model adaptive filtering. Effort will be devoted next quarter to a theoretical examination of this model and the results to be expected from the application of the adaptive beamforming technique to such signals.

## SECTION V

### DISCRIMINATION

#### A. CURRENT STATUS

1. Part of the discrimination task includes the investigation of the power of short-period NORSAR source spectrum measurements as discriminants.

A data base for this study is in preparation, which includes earthquakes and explosions at regional and teleseismic distances. A program to filter traces and compute spectra by the maximum entropy method is nearing completion.

2. The purpose of the first-zone discrimination study is to determine the capability of a Eurasian seismic station to discriminate among events at epicentral distances of less than 2000 kilometers using phase energy ratios. A frequency-time-power analysis was performed on near-field events recorded at NORSAR. In every case the ratio of the S phase energy to P phase energy discriminated correctly between earthquakes and presumed explosions. The data base for this study is being expanded.

3. A method to extend the Herrin-Tucker network magnitude bias model to allow for non-uniformity in the station detection thresholds has been developed. This method applies maximum likelihood estimation to determine event network magnitude, given the individual magnitudes at the detecting stations and the measured noise levels at the non-detecting stations. It was found that an upward bias of from a half to one magnitude unit ( $m_b$ ) exists in the ordinary magnitude estimate for events near the threshold of a 10 element network. The maximum likelihood method removes this bias. A report has been submitted on this subject. This completes the contractual work on this task.

## B. FUTURE PLANS

1. NORSAR short-period source spectrum measurements in the next quarter will include corner frequency, roll off, and long-period displacement. Noise and system response corrections are major problems in computing accurate spectra, while absorption and diffraction may create problems in their interpretation. These problems will be dealt with in the coming quarter. Significant deviations of the corrected explosion sources from accepted scale laws for earthquakes will be taken as discriminants.

2. During the coming quarter we will complete the editing of our additional first-zone long-period NORSAR data and do a visual analysis of both short- and long-period data to measure travel times, amplitudes, and magnitudes. Moving window spectral analysis will be performed on all data and the energy ratios between various phases will be estimated. The effectiveness of these quantities as discriminants will be measured and reported on.

## SECTION VI

### SYSTEM ENGINEERING STUDIES

#### A. CURRENT STATUS

The Interactive Long Period Processing System (ILPPS) for the PDP-15 computer has been developed further toward becoming an operationally flexible interactive matched filtering package. An option to perform group velocity analysis of Rayleigh and Love waves has been integrated with the previously developed system, and an option to generate a hard copy of the information displayed on the CRT screen has been implemented. It is possible with this option to generate a hard copy using either the CALCOMP plotter or the VARIAN electrostatic printer/plotter.

Evaluation of the performance of the interactive system has been initiated to determine its operational practicality and what changes, if any, are required. Both the spectral analysis package for group velocity determination and the interactive complex cepstrum technique for extraction of later phases and multiple events are currently being evaluated.

Work is complete on interfacing the interactive system with data tapes generated by the Seismic Research Observatories (SRO).

The capabilities now exist to:

- Input a specified short- or long-period event or noise sample directly from an SRO field data tape to a disk file.
- For long-period data, the full signal analysis package developed in the ILPPS system is available to SRO data, once the above disk files have been generated.

- For short-period data, the capability exists to perform time window selection, bandpass filtering, and parameter measurements along the same lines as in the ILPPS system.

#### B. FUTURE PLANS

Evaluation of the interactive techniques will continue, with emphases on the expected performance in an operational surveillance system.